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Report of a Workshop on "Nuclear Power and the Risks of Proliferation and Terrorism," Woodrow Wilson International Center for Scholars, Washington, DC, April 25, 2006

It is widely viewed that an expansion of nuclear power would have positive energy, economic and environmental benefits for the world. However, there are concerns about the economic competitiveness, safety and proliferation and terrorism risks of nuclear power. Public acceptance is largely tied to these and other issues. While the threat has frequently been exaggerated by critics, the risks posed to the nuclear enterprise are real. Accordingly, the threat environment is critical to any dramatic growth in nuclear power in the United States, as envisaged by the Global Nuclear Energy Partnership (GNEP), and it is important to assess properly the threat and to understand its impact on nuclear power. In this context, the Los Alamos National Laboratory in cooperation with the Woodrow Wilson International Center for Scholars hosted a workshop on the relations between nuclear power and nonproliferation in order to debunk the myths surrounding the purported relations between nuclear power and proliferation/terrorism, to baseline the real connections and to assess past, present and future tools and approaches to ensure that the growth of nuclear power does not lead to a rise in the proliferation/terrorism threats. The following is a summary of key points and themes from the meeting.

The Debate on the Security Risks of Nuclear Power

From the very beginnings of the nuclear age, the dual (military-civil) nature of the atom has been recognized. The possible misuse of civilian nuclear power programs for military purposes was on the minds of the authors of the Acheson-Lilienthal Report, the Baruch Plan, the Atoms-for-Peace proposal and the international nuclear nonproliferation regime based on the Atoms-for-Peace bargain.

Those who believed we could manage the risks of nuclear power have recognized its inherent dangers, but pointed to the dedicated military programs of most proliferants as the real source of concern; those who were less sanguine about the prospect of harnessing a promising but dangerous technology in a world rife with conflicts argued against the use of nuclear power.

The debate, with its variations and nuances is now 60 years old. It has waxed and waned, depending upon real-world developments such as the concerns derived from extrapolations of dramatic, even exponential, growth in nuclear power and by the actual development of proliferation threats, notably the Indian program in the 1970s, the Pakistani program in the 1980s and the Iraqi, Iranian and North Korean programs in the 1990s and this decade. The accidents at Three Mile Island and Chernobyl have also greatly affected the debate.

In recent years, the debate is beginning to be reengaged on a level not seen since the 1970s. There are similarities between the debate now and 30 years ago, for example:

- expectations of a dramatic growth in nuclear power;
- concerns about reprocessing and plutonium use; and
- perceptions of rising proliferation and terrorism threats.

But there are major differences. On the one hand, today proliferation dangers appear greater than they did thirty years ago. They are also emerging from unanticipated sources, including nonstate actors. Moreover, the risks from HEU are now seen as greater. The prospect of nuclear terrorism is receiving unprecedented attention (although it was a factor in the 1970s). After 9/11, some concluded the danger of any use of nuclear power was too great to accept.

On the other hand, the desire for energy independence has led to increased interest in nuclear energy. And global warning concerns have convinced many, including staunch environmentalists, of the need to pursue nuclear power aggressively, even a closed cycle. Moreover, to address rising concerns, strong efforts to reduce nuclear power's risks/vulnerabilities are being proposed and undertaken, including efforts to avoid separation of Pu in the future.

The proposals by President Bush in 2004 and those of International Atomic Energy Agency (IAEA) Director General Mohammed ElBaradei have been seen in the context of this debate. The Bush Administration announced a new Global Nuclear Energy Partnership in 2006. GNEP has become, since its announcement, a focus of the debate, and a prism through which the debate's old and new features can be seen.

The Debate over GNEP

As part of President Bush's Advanced Energy Initiative, the Global Nuclear Energy Partnership seeks to enhance energy security while promoting nonproliferation through the expanded use of economical, carbon-free nuclear energy to meet growing electricity demand. It would achieve its goal by having nations with secure, advanced nuclear capabilities guarantee fuel services — fresh fuel and recovery of used fuel — to other nations who agree to employ nuclear energy for power generation purposes only. GNEP will involve closing the nuclear fuel cycle, destroying separated transuranics (e.g., plutonium, neptunium) in fast spectrum reactors, re-designing the waste repository to accommodate a dramatically different waste form and implementing an advanced nonproliferation/safeguards program. Not only acceptance for, but the success of, GNEP depends critically on early demonstration of the nonproliferation elements of and approaches to all GNEP closed fuel cycle elements.

If GNEP succeeds as planned, significant nonproliferation benefits could be expected, including:

- Slowing, if not halting, the spread of enrichment and reprocessing (ENR) technologies (and other sensitive nuclear technology);
- Creating a fully functioning, secure, effective and nondiscriminatory assured fuel supply/takeback regime that would enable the political acceptance of ENR limitations;

- Limiting fuel cycle activities and possession of direct use material to a small number of states, including the nuclear-weapons states defined under the Nonproliferation Treaty (NPT);
- Limiting inventories of separated transuranics, and ensuring they are rigorously safeguarded, protected and accounted for;
- Slowing, if not halting, further production of separated plutonium, as new recycling technologies allow the burning of plutonium in fast spectrum reactors without ever having separated it from other actinides; and
- Minimizing and disposing of waste, reducing potentially attractive targets for terrorists seeking recoverable nuclear material or material for a radiological dispersal device.

GNEP will not be a panacea. What will happen during the decades of fuel cycle transition is not clear. At least some states will inevitably develop virtual capabilities through their role in the fuel cycle, creating the prospect of a breakout. States with clandestine programs will remain a possible threat, as will nonstate actors seeking nuclear and radiological weapons. It was not expected that the proposal would work for all specific states of concern, including Iran, but that developing a coalition of states committed to GNEP would have considerable value in promoting both nuclear energy and nonproliferation around the world in the long term.

There will in any event continue to be risks associated with the proposed closed fuel cycle, including the prospect that material would be attractive to states and in a form that is potentially vulnerable to terrorists. Moreover, a growing number of reactors will create a demand for more enrichment capacity, as well as generate large amounts of spent fuel. Finally, there would be growing requirements as a result of take back to move spent fuel from around the world to a few countries, increasing transportation risks to some degree.

Beyond any such risks, domestic critics have argued that, at the very least, the commitment to a closed fuel cycle was premature, and that it could pose obstacles to an increase in the use of nuclear energy for power production. This view was expressed at the workshop. In this context, critics have also argued that the plan does not meet the spent fuel standard. The expectation is that intermediate UREX + product will meet the spent-fuel standard by keeping actinides and lanthanides commingled with plutonium in the product stream. At the last minute, or in a collocated facility with minimal time delay before use in the reactor, the lanthanides would be replaced with U and fuel produced. Weapon-usable material is always in a hot cell, and is never separately stored or transported. And, within the very tight process flow, other elements can be introduced into the hot cell so that even an insider could not seize weapon-usable material.
Critics have also raised the issue of costs. To the extent there are additional costs with the proposal, e.g., subsidies for takeback or for fast burner reactors, who will pay? Will the United States pay? It was noted that U.S. funding of various Cooperative Threat Reduction (CTR) programs may be a model, but that the possibility of taxing nuclear electricity generation might also be a means to pay for such costs.

GNEP has captured international interest as well. It was reported that the international response to GNEP has been positive to date. However, one participant who supported GNEP argued that its success depends not on DOE discussions but on a high-level diplomatic initiative along the lines of Kissinger's Washington Conference during the oil crisis of 1973-74, which led to the creation of the International Energy Agency (IEA). The IEA's initial role was to coordinate measures in times of oil supply emergencies. But during the last decades, the IEA's role has evolved as energy markets have changed.

In addition, discussions to date have shown that states committed to PUREX and MOX recycle were not likely to change their approach. It was suggested that change might be possible when those states needed to augment or replace capacity in the future, if the GNEP model is a reality at that time. Clearly, it was recognized that more work needed to be done regarding the harmonization of policies and goals among key states in a position to offer fuel cycle services in the world. GNEP is adjusting, in an effort to find common ground. It was noted that the US GNEP proposal and the Russia proposal for fuel cycle centers were not far apart.

As for states without fuel cycle capabilities, GNEP offers the prospect of obtaining nuclear energy for power production and other peaceful uses. The overarching vision and key elements of GNEP are directed to the realization of this objective, including the development of small reactors for export and the promise of reliable supply of fresh fuel and perhaps most importantly the takeback of spent fuel for disposal. Accordingly, it offers tangible benefits rather than eliminates or undermines rights. It is both fully consistent with and an attractive means of realizing Article IV rights.

Unfortunately, references to “fuel cycle states” and “reactor states” in the GNEP announcement have been interpreted as discriminatory, and seen as exacerbating the charges of discrimination made against the NPT. This terminology plays into the rhetoric of states such as Iran. Nothing could be further from the truth. It was argued that the bargain or deal envisioned in GNEP, in which states would forego ENR in exchange for reliable supply/takeback, would involve a fixed period of time rather than a commitment for all time. Thus, rather than creating permanent conditions for states, the GNEP approach contemplates the possible evolution of states positions vis-à-vis the fuel cycle.

There were other issues raised concerning the plan. On takeback, the prospect that, if realized, there would be one supplier (Russia) rather than multiple suppliers of spent fuel services was noted. The impact on reliability could be significant in such an event, and it was argued the United States should explore whether it could be involved. It was argued that early establishment of a spent fuel interim storage capability would be critical in order to obtain early buy in by key states.

A Fuel Leasing Proposal

Although the debate focused on GNEP, there was an independent proposal for fuel leasing put forward. It outlined the prospective strong interest of the nuclear industry to prevent proliferation just to protect their investment. On this basis, it was argued that the industry had an interest in minimizing enrichment and reprocessing. The only credible option, it was argued, was a consensual approach.

A lease approach would require user states to agree not to obtain fuel cycle facilities for an extended period. Those states with fuel cycle capability would agree not to provide fuel cycle facilities for same period as well as to provide cradle-to-grave, guaranteed, attractively priced fuel services. In this voluntary deal, suppliers would receive revenues, while users would receive fuel and a solution to the spent fuel problem.

Key obstacles involved process issues, including the need for commercial entities and energy and economics ministries to work out details. It was recognized that foreign ministries must, of course, be involved, but it was argued that the discussion should not be dominated by nonproliferation and arms control experts or we will never escape the prison of Article IV v. Article VI debates

Other obstacles involved substantive issues, including:

- The need for subsidies;
- Security of supply;
- Technological leadership and technology sharing; and
- Asymmetrical obligations.

It was noted by some participants that all of these issues confront GNEP as well, and would need to be addressed if the Partnership is to be successful.

Proliferation and Terrorism Risks Today

As noted, the expansion of nuclear power inevitably raises concerns about proliferation and terrorism risks. While these risks have often been exaggerated in the past--every reactor is a “bomb factory”--it is clear that real threats exist, as do a broader set of risks. Understanding and addressing the risk/threat environments area is critical to any dramatic growth in nuclear power in the United States, as envisaged by the Global Nuclear Energy Partnership, and around the world.

Threats posed to the nuclear enterprise are changing, and today covers a wide range of possibilities. Terrorist acts could involve state or nonstate actors, or state support of nonstate actors. The threat could take a variety of forms. Nuclear proliferation can involve everything from the establishment of a virtual capability to the production of weapon-usable materials to a full weapon program. Nuclear and radiological terrorism can range from the threat or use of a nuclear weapon to the dispersal of radiological material and the attack/sabotage of nuclear facilities or transport.

Not only are there different forms of proliferation and terrorism, but each differs in terms of enabling and other factors such as materials/facilities involved, technological sophistication required of the state or nonstate actors, intentions of the state or nonstate actors, etc., and, most notably, the probability of successful execution and the consequences of the attack.

Risks and threats need to be better understood and calibrated, if we are to design effective nonproliferation and physical security responses. Because of the fluid and dynamic security environment, this task is more difficult today than it ever has been. On the basis of the discussions, risks include:

- the comparative risks of proliferation v. terrorism;
- the link of these risks to civilian nuclear power;
- the differences between Pu and HEU, as well as open v. closed fuel cycles in this context;
- the comparative costs for management of risks; and
- the comparative risks of the pursuit of nuclear growth v. the impact of not doing so in terms of energy security, environmental stewardship and other issues.

In this context, a key feature of the debate was the role of nonstate actors. It was recognized that the traditional nuclear fuel cycle offers little opportunity for nonstate actors, but that other aspects of civilian nuclear activities may be more susceptible to theft or diversion. Such nonstate actors must be assumed to be well-financed, well-organized, operating out of multiple independent cells and possibly suicidal. It was also recognized that HEU was more interesting to nonstate actors who seek a usable weapon. To address this threat, the solution for most aspects of civilian nuclear use is phasing out HEU, which also reduces dual-use concerns on the front end of the fuel cycle.

The risk posed by nonstate actors using Pu was debated. On the one side, it was argued that those seeking a symbolic or radiological impact will not care very much what kind of material they get. Avoiding Pu separation was seen as the key, as differences between weapon-grade and reactor-grade Pu are overstated.

On the other hand, it was argued that the concern of those who oppose reprocessing to avoid the availability of separated plutonium that might somehow be stolen is misplaced. Great care in handling the separated material is certainly required. It was noted that some countries have been doing this for more than 30 years without losing any Pu. Moreover, it was argued, the prospect of a terrorist group building an implosion device with reactor-grade plutonium is not realistic. Such groups would, it was suggested, attempt to steal or buy an already assembled weapon, and programs that strengthen controls over existing weapons are vitally important.

Addressing Risks

Among the risks of proliferation and terrorism we confront today, there are those that were understood and anticipated from the beginning, along with those that have surprised us. Efforts to reduce, mitigate or eliminate these risks—at least those we anticipated—are decades old and comprise the nonproliferation regime, including safeguards and export controls.

The regime has evolved as threats have changed, as is evident in the case of safeguards. The post-Gulf War Iraqi program, the terrorist attacks of 9/11, the discoveries of additional States under the NPT pursuing clandestine programs and the associated revelation of an extensive nonstate nuclear procurement network have presented new challenges to domestic and international safeguards and to the international nuclear nonproliferation regime itself.

It was noted that within the constraints placed upon it by the international community and IAEA member states over the years, the international safeguards system has been effective in deterring misuse of declared facilities and diversion of nuclear materials inventories. Now, much more is being asked of IAEA safeguards, and meeting these new expectations will require lots of technical support and hard work.

An effective, strengthened international safeguards system, with a strong focus on searching for undeclared nuclear materials and activities, is essential to provide confidence that shared nuclear technologies and expertise, as well as nuclear materials themselves, are not being diverted to weapon programs.

The IAEA is adopting a fundamentally new approach to implementing safeguards based on the strengthening measures developed in the 1990s and the lessons learned from Iraq, North Korea, Libya and Iran.

Fundamental to the new approach to IAEA safeguards is information acquisition, evaluation and analysis along with inspections. The new approach is designed to provide an evaluation of the nuclear program of a state and not just each of its declared nuclear facilities.

The new IAEA system is more flexible, and should be well suited to allocating scarce resources to where they are needed most in countering proliferation risk. To deal with the growth in nuclear energy use, it is essential that this more flexible international safeguards system be credible and efficient.

In addition to evolving safeguards and other traditional regime elements, initiatives to address new and emerging threats, and unanticipated developments—from the end of the cold war to the rise of terrorism—have been especially prominent in the last 15 years. Among these are critical initiatives involving threat reduction, detecting, and interdiction, such as the CTR, Material Protection, Control and Accounting, Second Line of Defense, including the Megaports Initiative, the Proliferation Security Initiative, the Global Initiative for Proliferation Prevention, the Plutonium Production Reactor Agreement, the HEU deal and the Global Threat Reduction Initiative.

Finally, new attention to an old idea – proliferation resistance – has grown and can be expected to grow in the years ahead. Although the concept is not well defined and at times oversold, the idea of proliferation-resistant small reactors with long-lived cores is among the new ideas for addressing underlying proliferation concerns, while increasing the attractiveness of nonproliferation activities.

All of these activities are important, as efforts to reinforce and reform the nonproliferation regime. All are independent of GNEP but will be critical to GNEP’s success. But they may not be sufficient to address future threats.

Responding to Tomorrow's Threats

Beyond the responses of today and their evolution, what do we need to ensure we can respond to tomorrow's threats, some of which we will not have prepared ourselves to address?

Our record of anticipating threats has not been great. There is a need for improved capabilities in this regard. Even with the best capabilities, however, we will likely still be surprised. The threat is dynamic and we must have the tools critical to respond effectively and rapidly to any new threats.

Accordingly, there is a real need to maintain a robust R&D effort to ensure we have tools available to meet tomorrow's threats.

A key requirement is the development of a defense-in-depth safeguards/security approach that can be fully responsive to emerging threats, which requires cutting-edge threat assessment capabilities. Elements of defense-in-depth include, inter alia:

- state-of-the-art instrumentation and methodologies for materials detection, measurement, accounting and tracking, including sensor platform integration;
- enhanced containment and surveillance, including portal and area radiation monitoring, and measures to assure the absence of materials or radiation signals;
- integration of access denial and transparency elements of physical protection and safeguards; and

- integration of traditional process monitoring with non-traditional indicators, such as detection of radiation signals where they should not be, questionable movement of equipment and people, etc.

Next generation safeguards technologies for GNEP and future needs will include:

- integrated facility design to enable advanced safeguards and optimize proliferation resistance;
- intrinsic transparency in facility operations; and
- more robust integration of physical protection and safeguardability.

There is also a need to utilize systems analysis to evaluate design tradeoffs between facility operations, safeguards effectiveness and cost, as well as to assess the effectiveness of an integrated safeguards system as a whole.

There are opportunities to improve physical protection against sabotage or theft, which include the following:

- Integration of human performance programs to simultaneously achieve security, safety, and reliability goals;
- Background screening, two-man rules, tagging/sealing of cabinets/equipment, etc.;
- Use of moderate radiation barriers, hot cells and shielded transport casks to provide substantial intrinsic barriers to theft of materials for use in explosives; and
- Maximized use of passive safety and other equipment in new reactor designs.

For safeguards and security, as well as safety, it is necessary to know the location of nuclear materials. As a consequence, there must be a strong integration between process instrumentation and safeguards designs. If these issues are addressed at the same time, from the beginning of design, there are substantial benefits.

Conclusions and Next Steps

Public acceptance of GNEP, both domestically and internationally, depends to a significant degree on whether it can promote rather than undercut nonproliferation objectives and initiatives. A key milestone will be the early demonstration that all facets of the program can incorporate robust nonproliferation features, including advanced safeguards and proliferation resistance. An enhanced, systematic, defense-in-depth approach to nonproliferation that acknowledges the changing threat space and new technological possibilities opened by GNEP is essential.

The prospects for GNEP are also dependent on developments in the wider nonproliferation arena. There will be residual threats, including breakout proliferation and terrorism possibilities. It is clear that if the nonproliferation/counterterrorism environment is not being addressed, or not seen as being addressed, in an aggressive fashion, it will be difficult if not impossible to achieve the objectives of GNEP.

Accordingly, GNEP will need to incorporate nonproliferation in planning for both transitional activities and the desired end state. Many of the steps that must be taken during the transition—which will likely last decades--are being pursued as part of the current nonproliferation initiatives undertaken by the United States, the IAEA and others. Not only are these elements critical to the success of GNEP, but they remain valuable in their own right.

In this context, the nonproliferation benefits of the GNEP vision will have to be presented and debated in public fora, and nonproliferation considerations must be central to the international cooperative efforts envisioned in GNEP. To further thinking on these critical issues, we are planning to follow up this workshop with two workshops, one on the domestic and international debate over the nonproliferation impacts on GNEP, and one on international engagements and their nonproliferation dimensions.